Appendix 10-B

Better Protection from Stream Channel Erosion

Studies now show that, depending on the setting, natural channels are shaped by rainfall events ranging from the 0.9-year storm to the 1.8-year frequency storm event. In suburban and rural settings, the channel forming storm is more likely to be near the high end of this range (1.5-year to 1.8-year storm). This storm frequency allows the channel to maintain a state of equilibrium with regard to natural sediment load transport and natural vegetation, which helps to stabilize channel banks.

Note, however, that a peak discharge rollback requirement does not address the increase in the *frequency* of that peak runoff rate. Urbanization usually increases the amount of impervious cover, resulting in less infiltration, less initial abstraction and less depression storage. Consequently, it takes less rainfall to produce the same *volume* of runoff. Therefore, the *peak rate of runoff* that normally occurs with a 2-year frequency storm before development, may occur several times a year following development.

To compound the problem, a detention basin stores the increased *volume* of runoff from a developed area and releases it at the pre-development rate. The *duration* of this discharge is much longer than the pre-development condition, keeping the soils of the bank saturated for a longer time. The peak rate and velocity may be at pre-development levels, but by receiving the pre-development rate for a longer *duration*, coupled with the increase in *frequency*, a stable earth-lined channel can quickly degrade. And, in fact, this is what has been happening to stream channels receiving runoff from most development sites.

The increased frequency of a specific discharge can be illustrated by considering an undeveloped watershed which, during a two-year frequency storm (3.2 inches of rain in Virginia), generates a theoretical peak rate of runoff of 15 cubic feet per second (cfs), and a corresponding volume of runoff of 0.52 watershed inches. We will assume that this two-year frequency flow represents the channel forming, bankfull discharge. After the watershed has experienced development (32% imperviousness) along with the associated improved drainage conveyance systems, the same watershed requires only 1.6 inches of rainfall to generate that same theoretical bankfull discharge of 15 cfs. This means that the channel will now experience bankfull flows at an approximate increased *frequency* of every three to six months rather than once every two years. In addition, for the 2-year storm, the *volume* of runoff has increased to 1.15 watershed inches, more than double the pre-development runoff volume, which means a significant increase in the *duration* of the peak flow can be expected. Under this scenario, the receiving stream will experience a significant increase in erosive flows.

Designs that effectively prevent stream channel erosion evolve from the study of stream channel geomorphology. Several studies have indicated that the level of erosion (or bed-material load) is a function of the difference between the flow velocity and the *critical* velocity.(McCuen, 1987). The critical velocity is a function of the type of soil of which the channel bed is composed. The studies indicate that the amount of bed sediment moved is a function of the duration of time during which the velocity is greater than the critical velocity. According to McCuen, this explains from a conceptual standpoint why the duration of flow is just as important as the rate of flow. Further, it may explain why detention basins may actually increase the erosion compared to providing no control of the post-developed flows. When no control is provided, the flow tends to exceed the channel capacity and extend out into the floodplain; thus the velocity within the channel banks may not increase significantly even though the peak flow rate does increase significantly.

This should not be interpreted as justification for no control of stormwater runoff. Rather, it highlights the need for design criteria that replicate the pre-development sediment load transport characteristics of the channel. Several methodologies have been recommended, some of which are very subjective as they are based upon the ability of the designer to analyze and interpret the stream sediment and shear stress characteristics. This could easily become an expensive and cumbersome methodology, especially in localities that do not experience significant development pressure. The review and approval process could become bogged down in the analysis of field data and trying to verify the channel characteristics, especially when the requirements of the field work may be different for every project.